(b) Construct a Box-Behnken design for this problem.

(c) Since there are only 27 candidate design points, construct a 10-run design that is a D-optimal subset of the 27 candidates. Suggest one of the points that could be replicated three times to test lack of fit.

(d) Use the `Vdgraph` package to make variance dispersion graphs or fraction of design space plots for each design. What design do you prefer? Why?

(e) Use a catapult to actually run the experiments you have planned.

(f) Fit the general quadratic model to the data, using the `rsm` function and check the adequacy of the model.

(g) Using numerical optimization, contour plots, or simply evaluating your prediction equation over the 27 possible settings, determine the settings (one of the 27 possible) that you predict would result in a distance closest to exactly 12 feet.

(h) Test the settings you determined in (g). Is the distance close to your predictions?

6. Consider the experimental region shown in Figure 10.9, where $-1 < x_1 < 1$, $-1 < x_2 < 1$, and $x_2 \geq -2x_1 - 2,\ x_2 \leq -2x_1 + 1$.

(a) Construct a grid $\pm\frac{1}{2}$ of candidate points in the $(x_1,\, x_2)$ design region.

(b) Construct a 10-run D-optimal subset of the candidate points for fitting the general quadratic model.

7. Consider the first order kinetics model for the decomposition of dinitrogen pentoxide dissolved in carbon tetrachloride: $C = Ae^{-kt}$ where C is the concentration of dinitrogen pentoxide at time t. The parameters are: A the initial concentration, and k the rate constant.

(a) Linearize the model by taking the partial derivatives $\frac{\partial C}{\partial A}$, and $\frac{\partial C}{\partial k}$.

(b) Construct a grid of candidate points in the experimental region range: range $1 \leq t \leq 12$ using the initial estimates $A = 1.41$ and $k = .25$.

(c) Use the `OptFederov` function to construct a 4-run D-optimal nonlinear design for this model.

8. Consider the data in Table 10.1.

(a) Fit the general quadratic model using the `rsm` function as shown in Section 10.6.1.

(b) Use canonical analysis or ridge analysis to determine the conditions that result in the maximum workability of the cement grout within the spherical region $-1.68 \leq x_i \leq 1.68$ for $i = 1$, to 3 in coded units.

9. Consider the kinetic model ($C = Ae^{-kt}$) from Exercise 7. The data shown below was obtained by running experiments to fit model.